[COMMITTEE PRINT]

# EUROPEAN OVERSIGHT TRIP

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## REPORT

TO THE

## COMMITTEE ON SCIENCE AND TECHNOLOGY HOUSE OF REPRESENTATIVES

NINETY-EIGHTH CONGRESS

SECOND SESSION

**Serial FF**

OCTOBER 1984

Printed for the use of the Committee on Science and Technology

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## LETTER OF TRANSMITTAL

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HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
*Washington, DC, September 20, 1984.*

*To All Members, Committee on Science and Technology:*

There is transmitted herewith a report on an oversight review of European science and technology activities conducted during the period September 5 through 11, 1984.

The oversight review of key aeronautics, energy, environmental, and university research activities was designed to provide the Members of the Committee with an overview of European activities in those areas falling within our jurisdiction. In addition these discussions with aviation, energy and space officials, as well as those engaged in environmental and university research, provided valuable insights into activities and attitudes of our European allies.

I commend the report to your attention.

Sincerely,

DON FUQUA, *Chairman.*

## LETTER OF SUBMITTAL

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HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
*Washington, DC, September 20, 1984.*

Hon. DON FUQUA,
*Chairman, Committee on Science and Technology,*
*House of Representatives, Washington, DC.*

DEAR MR. CHAIRMAN: I am sending you this report on the Committee Oversight Trip conducted between September 5 and 11, 1984. The report includes the highlights of the facility visits, summaries of the discussions with U.S. and foreign officials and a report on each.

On your instructions, the Committee developed a plan to conduct a review of key aviation, energy, environmental and university research activities as time permitted. The schedule and oversight activities were designed to give Members and staff a first-hand opportunity to assess the status and performance of our European allies in developing aviation technologies, competing with the U.S. in aircraft production, conducting magnetic fusion research and performing environmental research and monitoring, as well as addressing problems and opportunities in university research.

In my opinion, the Committee staff has provided excellent professional support to this oversight activity as evidenced in the attached report.

Sincerely,

HAROLD P. HANSON,
*Executive Director.*

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## INTRODUCTION

The Committee on Science and Technology has as its jurisdiction all civilian Research and Development activity taking place in the United States. This responsibility covers such diverse areas as Energy, Space, Aeronautics, Transportation R&D, Science and Science Policy, and Evironmental R&D.

Subsequent to the completion of reporting all the fiscal year 1985 authorization bills and reports for which the Committee has jurisdiction, the Committee conducted an oversight trip to Europe to review certain parallel activity taking place in England and Norway. The major emphasis of the trip was placed on aeronautical activities, energy and environmental research and development, and university research. As can be seen in the contents page of this report, the Committee conducted parallel meetings with various agencies and institutions and made visits to several facilities.

The Committee was ably complemented by Members of the Ways and Means and Appropriations Committees.

Members participating in the European Oversight Trip were:

COMMITTEE ON SCIENCE AND TECHNOLOGY

Don Fuqua (D-Fla.).
Larry Winn (R-Kan.)
Tom Lewis (R-Fla.)

COMMITTEE ON WAYS AND MEANS

Ronnie G. Flippo (D-Ala.)

COMMITTEE ON APPROPRIATIONS

Eldon Rudd (R-Ariz.)



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## COMMITTEE ACTIVITIES

### HIGHLIGHTS

*U.S. Embassy*

The embassy staff briefed the delegation on political, economic, commercial, and scientific status in the United Kingdom.

Politically, the Conservative (Tory) Party is firmly in control of the government. The Labour Party has moved to the left and has been weakened. A long coal strike is politically motivated to attempt to unseat the Conservatives.

In the economic area inflation has dropped from 20% to less than 5%, although unemployment is still high (12%). Government spending has been reduced and denationalization of selected industries will continue.

The embassy seeks to encourage commercial exports to the UK, particularly through the "Matchmaker" program for those who have not exported before.

Science and technology funding has been reduced, and the government encourages increased assistance in this area from industry.

*Aeronautics*

*Farnborough International Air Show '84*

Farnborough '84 was the world's largest international aerospace exhibition of 1984 and the biggest Farnborough show ever in terms of exhibit space sold. The products of over 530 areospace manufacturers were on display in the exhibit halls with about 150 aircraft on view. New aircraft this year included the Tornado F2, Turbo-Firecracker high performance trainer, Boeing 737-300, Harrier II (AV-8B), Tigershark F-20, Yugoslav Eagle fighter, Russian IL-86 wide body transport, Mil-26 heavy lift helicopter and An-72 twin jet STOL transport; and Skyship 600, a new airship. A highlight of the flying demonstrations held each afternoon was the precision performance of the RAF Red Arrows.

A common feeling at the show was the end of the European aerospace recesssion. This feeling is reflected in the rise of spares consumption by airlines as flying hours and capacity rise. As for the show itself, Farnborough continues to reflect the ambivalent attitude of companies toward such expensive exhibitions. Costs can easily run to half a million dollars for a chalet and hall space, and up to $2 million if an aircraft is included. This has continued to raise questions about whether the benefits justify such expenditures. Westinghouse, Grumman, General Dynamics and Lockheed all stayed away this year. McDonnell Douglas came back, LTV was

back after skipping Paris last year, and Pratt & Whitney was back, possibly reflecting a new, more aggressive marketing stance after losing several orders to G.E. The trend toward national stands in exhibit halls rather than individual company displays continues to grow. The future outlook is the same as before. Companies will drop out and reappear when they have something new to sell.

*Rolls Royce Aircraft Engine Facility and International Aero Engines Engineering Center*

The Rolls Royce Aircraft Engine Facility, the largest of its kind in the world, produces engines for all Rolls Royce powered civil and military aircraft, helicopters, power stations, and gas pumping plants.

The International Aero Engines Engineering Center will direct the engineering design and development of the advanced technology V2500 turbofan engine. The V2500 engine, designed for the new generation of 150-passenger aircraft, will improve fuel efficiency by 50% over existing short-range transports currently in service.

*Energy*

*Joint European Torus (JET), Culham Laboratory*

Despite complex institutional arrangements, the JET directorate has managed to achieve excellent quality assurance in equipment procurement and the Project has been held on schedule and within estimated cost.

To date, the JET experimental accomplishments are impressive with significant plasma ohmic heating levels and confinement times having been achieved under conditions of long-pulse duration.

JET/TFTR (Tokamak Fusion Test Reactor) cooperation is very solid and the revised U.S. fusion timetable means that these devices should be achieving burning plasmas at roughly the same period, 1989–1990.

The JET group recognizes that the perception of the Magnetic Fusion Energy program is clouded by its hybrid nature, because although there is a lack of urgency for demonstration at test reactor conditions, the program requires expensive devices for successive experiments approaching steady-state burning plasma conditions at larger and larger scale. The Europeans believe that this perception is a contributing factor to the recent budgetary problems which the U.S. program has suffered.

The JET group believes that the next magnetic fusion device should be a long-pulse ignition machine (very similar to the U.S. Tokamak Fusion Core Experiment (TFCX) design) that provides virtually steady-state burning plasma operation.

The JET experimental prospects for achieving energy break-even will require improved impurity control and 25 megawatts of effective auxillary heating at high plasma densities. The JET team is cautious but optimistic about reaching this milestone with a deuterium-tritium (D–T) burning plasma by 1990.

*Environment*

*Norwegian Institute for Water Research (Norsk Institute for Vannforskning) NIVA*

The Norwegian acid rain research program is among the most extensive and far-reaching in Europe. The initial research efforts culminated in 1980, with release of a report entitled "Acid Precipitation—Effects on Forests and Fish," a well-documented and highly regarded analysis of the environmental impacts associated with acid.

In Norway, current research is being conducted on the processes involved in fresh water acidification in order to predict the effect on water chemistry from varying degrees of deposition. An innovative research project entitled "RAIN" (Reversing Acidification in Norway) is designed to examine the nature and rate of acidification of sensitive lakes and the rate at which acidification may be reversed. In addition, Norway is experimenting with liming of lakes and watersheds as a temporary solution to acidification.

Norway participates in the European Monitoring and Evaluation Program, which consists of 80 stations throughout Europe that monitor air quality and/or precipitation. The program functions adequately in Western Europe; however, Eastern European countries provide only minimal information.

Norwegian scientists are hopeful that Western European governments will reach a cooperative agreement on controlling acid precipitation.

*University Research*

*Oxford University*

Universities in Great Britain receive government support through what is referred to as a dual support system. The universities receive institutional and salary support from University Grant Committees and receive support for particular science programs from Science Research Councils.

In Great Britain the government supports basic science across the board while expecting industry to shoulder responsibility for applied or near-term research.

The government also selectively supports what is called strategic science. Some feel that in the recent past the Research Councils have been putting more money into applied and strategic science at the expense of basic science.

Industry in the United Kingdom is less willing to shoulder risk than industry in the United States.

The present government has announced intentions to move toward contracts of 5–10 years for professors and away from tenured positions.

The British attach significant importance to international cooperation particularly in high energy physics and large science programs.

*University of Oslo*

During a half-day visit to the University of Oslo, discussions about the Norwegian system of government support for research

were held. That system is characterized by a large number of research institutes, government laboratories and research councils which interact in complex ways. A Committee of the Storting, the Norwegian parliament, reviews government policies and expenditures for research and development.

*Space*

*Department of Trade and Industry*

Great Britain does not have a separate national space program but pursues space activities through participation in the European Space Agency programs.

The British have emphasized application satellite activities.

Space activities in the past have not received high priority.

Great Britain is looking at the priority afforded space activities and many feel that the priority of space activities will increase in the future.

Great Britain has given consideration to more significant involvement in the Space Station activities.

# REPORT

## U.S. EMBASSY

### COUNTRY TEAM BRIEFING

Date of visit: September 6, 1984.
Location: U.S Embassy, London, England.

The delegation was briefed at the U.S. Embassy by:
Mr. Richard McCormack, Political Counselor.
Mr. Tim Deal, Economic Counselor.
Mr. Jerry Marks, Commercial Counselor.
Mr. Robert Stella, Science and Technology Counselor.

Mr. Richard McCormack, the embassy's Political Counselor, provided an overview of the current political situation in Britain and recent historical developments. When the Conservative (Tory) Party was defeated by Labour in the election of 1974, it initially accepted a substantial portion of the Labour initiated legislation. This approach broke down, however, and former Prime Minister Heath, then Tory Party Leader, was defeated by Margaret Thatcher. Mrs. Thatcher has been Party Leader for the last 10 years, and has been Prime Minister for the last five years. During that time the right wing of the Conservative Party has become dominant. Cabinet members who represented the traditional Tory positions on many policy matters have been replaced by her followers who are less willing to pursue traditional Tory policies. This has been made possible by the fact that the Conservatives hold 397 seats in the House of Commons out of a total of 650 seats. In comparison, the Labour Party currently holds 209 seats.

The Labour Party, since its defeat in 1979, has recommitted itself to a strong socialist policy. It has moved left and also has limited the powers of its leader. Power within the party has shifted to the labor unions. As a result, Neil Kinnock, a Welshman, has not yet been able to establish himself as a strong party leader. In the defense field, Mr. Kinnock is committed to unilateral nuclear disarmament. But the British people as a whole do not appear to support this policy.

While the former leader, Mr. Foote, was opposed to many U.S. policies it appears that Mr. Kinnock wants to reestablish good relations with the U.S.

The third political grouping, the new Liberal-Social Democratic Alliance, has taken up the middle ground, resulting from the shifts of the Tories and Labour. The Alliance has gained up to 50 percent in some polls, but because the voting system is not proportional it has a much smaller representation in the House of Commons.

The next election will not take place until 1986 or 1988, and there is at this time no visible challenge to Mrs. Thatcher as prime minister or party leader.

The British coal strike is centered not on wages, but rather on the National Coal Board's policy of closing marginal pits. Beyond that, however, it is very much a political strike. It is led by Miners Union (NUM) leader, Arthur Scargill, a radical, who has said that he wants to "turn off the lights" in Britain.

Mrs. Thatcher has a very positive attitude toward the United States. Both she and the Foreign Office show every desire to coordinate British foreign policy questions with the U.S. However, the Prime Minister is also a strong nationalist and she will speak for British interests when necessary.

With respect to the Falklands, future British policy is oriented toward the reestablishment of good relations with Argentina. But the Prime Minister will not yield British sovereignty over the islands. Although the war over the Falklands was costly, and the maintenance of a British military presence in the islands continues to demand significant resources, this issue has faded from public visibility in Britain and there is little debate on the matter.

Mr. Tim Deal, the embassy's Economic Counselor, provided the delegation with an overview of recent developments. In this area Prime Minister Thatcher has similarly dominated British policy. When she took office, there was a widespread feeling in the country that not much beyond a continuation of strong government control of all aspects of the economy could lead to an economic turnaround. Her policy, however, was to reduce government interference in the national economy. Her argument was that as a result of reductions in taxation and regulation, entrepreneurs would be given freer rein. The government's policy initially produced an inflation rate of 20 percent, and Mrs. Thatcher dropped very significantly in the polls.

Today, however, Mrs. Thatcher's policies, embodied in the "Medium Term Financial Policy," have, according to the Tories, produced an inflation rate of less than five percent. However, unemployment is still a problem at 12 percent. The budget is still running a significant deficit, in part because of a stable rate of taxation on individuals and a reduced rate for industry. However, much progress has been made reducing public spending, and as part of these reductions, funding for scientific research has been reduced. Further efforts will be made to reduce the deficit. The policy of denationalizing oil, automobiles, British Telecon, and British Airways will be continued, although there is a question of how much the financial markets can absorb.

A discussion of the embassy's strong effort to encourage U.S. firms to strengthen their exports to Great Britain was presented by Mr. Jerry Marks, the Commercial Counselor. American companies

today have a $30 billion investment in Great Britain. In the matter of possible additional restrictions by the U.S. on the imports of steel products, Britain, as a member of the European Community, believes that the agreement on alloy steels negotiated with the U.S. last year should be sufficient to avoid the imposition of U.S. quotas. The European Community is the spokesman for the British in this area. The "Matchmaker" program seeks to encourage American companies who have never before exported their products to participate in overseas markets. Mr. Marks urged members of the delegation to encourage individual firms throughout the United States to take a stronger interest in exporting their products. He noted the presence of Commerce Department and Small Business Administration representatives throughout every region of the U.S. who can be of help.

Mr. Robert Stella, the Counselor for Science and Technology, gave the delegation a brief overview of recent developments in British science policy. As a former research chemist and a former Minister for Science and Education, Mrs. Thatcher is well informed about matters of science policy. Government reductions in science funding have been accompanied by government encouragement of universities and the scientific community to seek broader cooperation with and funding by industry. Another notable aspect of the government policy for science education is the policy of placing a computer in every school in the country.

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## AERONAUTICS

### FARNBOROUGH INTERNATIONAL AIR SHOW '84

Dates of Visit: September 7–8, 1984.
Location: Farnborough, England.

A notable addition this year to the Farnborough Show was the Soviet Union which flew in its version of the jumbo jet, the 350-passenger Ilynshin II–86; the 44,000 lb. payload Mil Mi–26 helicopter that is preeminent worldwide in heavy-lift capability; and the Antonov An–72 light STOL transport that looks to be a copy of the over-the-wing blown flap Boeing YC–14 light military cargo transport. Both the Mi–26 and the An–72 took part in the daily flying at Farnborough. Neither had flown at the Paris show in 1981, their last performance at an international air show.

The Mi–26 did not do anything fast or maneuverable in keeping with its intended purpose as a heavy-lift utility aircraft. The An–72 on the other hand was impressively quiet on short takeoff and steep climbout. It did a steep wingover over the runway and flew close-in approaches with tight turns, showing more maneuverability than other Soviet transports flown at Paris.

The flight line at Farnborough illustrated the recent trend toward derivative aircraft rather than totally new models. The new aircraft included the de Havilland Aircraft of Canada Dash 8, CASA/Nurtanio CN–235 and the Brazilian Embraer 120 Brasilia and 312 Tucano trainer. The fact that all of these except the Tucano are small transports shows the importance of that market in the wake of airline deregulation. Among the derivative aircraft were the Airbus Industrie A 300–600, Boeing 737–300 with a unique nacelle designed to allow enough ground clearance for the CFM–56 engines, French Dassault Mirage 2000N and Mirage 3NG and British Westland Lynx 3 helicopter.

*Technology Highlights*

*British Aerospace Dynamics.*—Making its first appearance at Farnborough was Rapier Laserfire, the new low-cost palletised weapon system. Other high technology items were a working ring laser gyroscope, the first all-British design, and a cryogenic engine for continuous cooling of infra-red sensors. An experimental fibre-optic gyro and units of a new airborne linescan surveillance system were on show. New developments in radome materials were featured. A model of the six-blade advanced technology propeller for the ATP airliner was exhibited together with a layout depicting a new concept for the automatic, rapid and detailed examination of air cargo loads.

*Ciba-Geigy's Bonded Structures Division.*—This year celebrating 50 years in the aircraft industry at Duxford displayed several examples of state-of-the-art reinforced composite components.

*Dunlop Aviation Division.*—World leader in carbon brake technology, exhibited brakes for advanced civil and military aircraft including the Boeing 757, Airbus A310–300, BAe 146, ATP, AV–8B, Concorde, and the British Aerospace Experiment Aircraft Project (EAP). Dunlop's total capacity in braking systems was illustrated by the latest concepts in lightweight and radial tire designs and brake management systems incorporating digital anti-skid control to be supplied for the EAP. The ice protection systems supplied for the Shorts 360, ATP, Fokker 50 and Westland W30–200 helicopter, demonstrated a new integrated system and structure concept for improved economic and technical performance.

*Ferranti plc.*—Featured a range of advanced avionics and electronic systems. Notable exhibits included the 360° scan Seaspray 3 radar recently selected for the German Navy Sea Kings and a model of the new Sea Harrier radar, Blue Vixen. A foresight of the cockpit of future combat aircraft was presented by a mock-up aircraft instrument panel incorporating electronically generated displays. A new head-up display/weapon aiming computer and the FIN 1100 strap down inertial reference navigation system was also shown as well as new products in the fields of thermal imaging and RPV surveillance. An air traffic control simulator incorporating voice activated commands was on display. Other exhibits included the new FH22 attitude indicator and FA6 accelerator, gyro equipment, sighting systems, electronic fusing systems and a solid state recorder designed to monitor the in-flight performance of missiles and shells.

*Flight Refuelling Limited.*—Latest in its world renowned probe and drogue air refuelling equipment was Flight Refuelling's Mark Seventeen-T hose drum unit for the Lockheed TriStar tankers ordered by the Ministry of Defence for the Royal Air Force. Flight Refuelling's family of remotely piloted vehicles included Raven—a low-cost mini RPV capable of real time television surveillance and navigation via way points—and Falconet, a high performance remotely-piloted vehicle designed for low-cost procurement and equipped with Jato for zero-length launch. A Tornado drop tank in scale model form was indicative of Flight Refuelling's entry into the field of aircraft external tank production.

*IAL.*—Displayed state-of-the-art technology covering security, voice communications, airport and airline systems and environmental services. For the first time IAL's Rapiscan 3 was exhibited together with a range of associated metal and explosives detection equipment, closed circuit TV and access control equipment. IAL Voice Systems displayed a new visual control room air traffic control console housing the latest IAL Stratus voice communications switching equipment. Global Weather Dynamics, an IAL subsidiary, displayed a full flight control workstation to demonstrate its full aviation data services, together with satellite and radar colour displays. Fibre optic capability and the new RAF auto-triangulation system was featured.

*Marconi Avionics.*—The avionics company of GEC presented evidence of night vision experience with its complete range of thermal

imaging and FLIR sensors, advanced processing equipment and displays, including HUD, Head down displays and NV goggles. These result in a demonstrated ability to supply integrated night attack systems now, for new aircraft and retrofit. New technology for maritime, transport, ground attack and air defense aircraft and communications included RPVs, advanced signal and data processing "Strapdown" sensors, MI STD 1553 data bus applications, digital maps and digital data recorders.

*Plessey.*—Had ten individual businesses at this exhibition. Plessey Avionics displayed its major contribution to such projects as the NAVSTAR Global Positioning System, JTIDS and NIS, and introduced its new anti-jam communications system SHELTER. Plessey Radar unveiled its new advance technology antenna of the type 996 radar which will equip all Royal Navy new Type 23 frigates. The new military Watchman radar made its world debut. The civil version was also displayed together with the planar array antenna for the AR3D air defense system. Plessey Marine showed Cormorant, a new lightweight dipping sonar. Plessey Aerospace's new fuel pump, weighing less than 5 lbs and as fitted to the Boeing 737-300, was available for inspection as was the single Air Motor Servo, the device which vectors the jet engine nozzles of the AV-8B. Plessey Microwave Materials highlighted radar camouflage technology for aircraft hides and hardened aircraft shelters on the ground and 'stealth' measures for helicopters and RPVs in the air. Plessey Defense Systems, with unique experience in $C^3I$ systems, demonstrated with a live display how service commanders on land, sea and air can be helped in decisionmaking by advanced technology.

*Rediffusion Simulation.*—Presented for the first time a pilot's view of Computer Generated Image combat scenes with full weapons effects, developed for the United States Air Force F-15 mission training programme on its CT5A visual system. The scenes were viewed in pilot's eye perspective from a fighter-type cockpit. Also for the first time the company presented its approach to interactive computer based training with a full Systems Familiarization Trainer for the Boeing 747 aircraft.

*Rolls-Royce.*—Two new Rolls-Royce engines made their Farnborough debut—the Tay and the RTM 322. Three hundred Tays are on order for the new Gulfstream IV executive jet and Fokker 100 airliner. The RTM 322 is a new Rolls-Royce/Turbomeca project to provide a range of power units for helicopter, turboprop and turbofan applications in the 1,800-3,000 hp bracket. Rolls-Royce also displayed seven other engines.

## ROLLS ROYCE AIRPORT ENGINE FACILITY AND INTERNATIONAL AERO ENGINES ENGINEERING CENTER

Date of visit: September 10, 1984.
Location: Derby, England.

Principal officials who met with delegation were:

Mr. D. Davies, Vice President, Engineering, International Aero Engines.

Mr. Allan Smith, Director, Commercial Marketing, Rolls Royce.

The Rolls Royce Aircraft Engine Facility consists of a large number of plants spread throughout the city of Derby, England. Due to time limitations, much of the tour focused on the Rolls Royce precision casting facility, the disc and turbine production facility, and the design facility. The Rolls Royce precision casting facility, alone, has a floor space of over seven acres. It produces castings, using approximately twenty different alloys, for all Rolls Royce powered civil and military aircraft and helicopters.

Rolls Royce is currently beginning to implement plans for greater automation of facilities, including greater use of robots for precision casting, the automation of engineering plans and design through the use of computer graphics, and the use of robot vehicles to deliver parts during the manufacture of discs, turbines and compressors.

International Aero Engines is an international consortium established to produce the V2500 turbofan engine. Members of the consortium are Rolls Royce (U.K.), United Technologies (U.S.A.), Japanese Aero Engines Corporation, which includes participation by Kawasaki, Mitsubishi, and I.S.I. (Japan), Motoren-und Turbinen-Union (Germany) and Fiat (Italy).

International Aero Engines and Airbus Industries have recently signed an agreement to develop and market a version of the Airbus A320 150-passenger aircraft powered by the IAE V2500 turbofan engine. IAE has identified twenty-five candidate airlines that may have requirements for A320, McDonnell Douglas MD–80 series and Boeing 737 or 7–7 aircraft powered by the V2500.

The current V2500 schedule consists of a 7½ development program managed by the IAE Engineering Center at Derby, England, but with various tests conducted at Pratt and Whitney in Hartford, Connecticut, and at Rolls Royce in Derby, England. Later tests will also include other members of the consortium. The schedule includes a first engine test in February, 1986; delivery of the first non-certified propulsion unit in January 1988; engine and thrust reverser certification in April 1988, first flight of the V2500-powered Airbus A320 in August 1988, and first delivery of a production aircraft in March 1989.

International Aero Engines was incorporated last year in Zurich, Switzerland. The IAE Board of Directors consists of thirteen members representing the five countries and companies that make up the engine consortium. However, the consortium agreement provides for management by Rolls Royce and Pratt and Whitney for the first ten years, with IAE management alternating between the two companies. The workshare of the engine development has been carefully constructed and agreed to by all of the various companies. Rolls Royce will have a workshare of 30% for the development of the high pressure compressor. Pratt and Whitney also has a 30% share of the work for their development of the hot section, Japanese Aero Engines Corporation has 23% of the work with the development of the large fan section, with the technical assistance of Rolls Royce. MTU has an 11% share for the low pressure turbine, and Fiat has 6% with the gearbox and rear bearing. The profits from the engine will be shared in proportion to the workshare, with minor variations based upon relative inflation, currency variables, and other local economic considerations.

The British government has announced that they will make available approximately $87 million to Rolls Royce to partially fund its participation in the IAE V2500 multinational turbofan engine program. The government funds will be recovered by a levy on each engine sold, and would continue to be applied even after the initial investment is recouped.

INTERNATIONAL AERO ENGINE

# V2500

38-613 O—84——4

# INTERNATIONAL AERO ENGINES

## THE COMPANY

Incorporated in Zurich, Switzerland

Has received all member companies' board and government approvals

All export license requirements met

Headquarters in East Hartford

IAE engineering offices in Derby



J30114-1
842303

# INTERNATIONAL AERO ENGINES

## EXECUTIVE BOARD

13 members

- 3 nominated by each UTC, RR, JAEC
- 2 nominated by each MTU, FIAT

Responsible for general management



RAB12TX 008

# MANAGEMENT OF THE CALLABORATION

## A JOINT COMPANY CALLED "IAE-INTERNATIONAL AERO ENGINES"

| | |
|---|---|
| Rolls-Royce | 30% |
| United Technologies | 30% |
| Japanese Aero Engines Corporation | 23% |
| MTU-Motoren-und Turbinen-Union, München GmbH | 11% |
| Fiat Aviazione SPA | 6% |
| | 100% |



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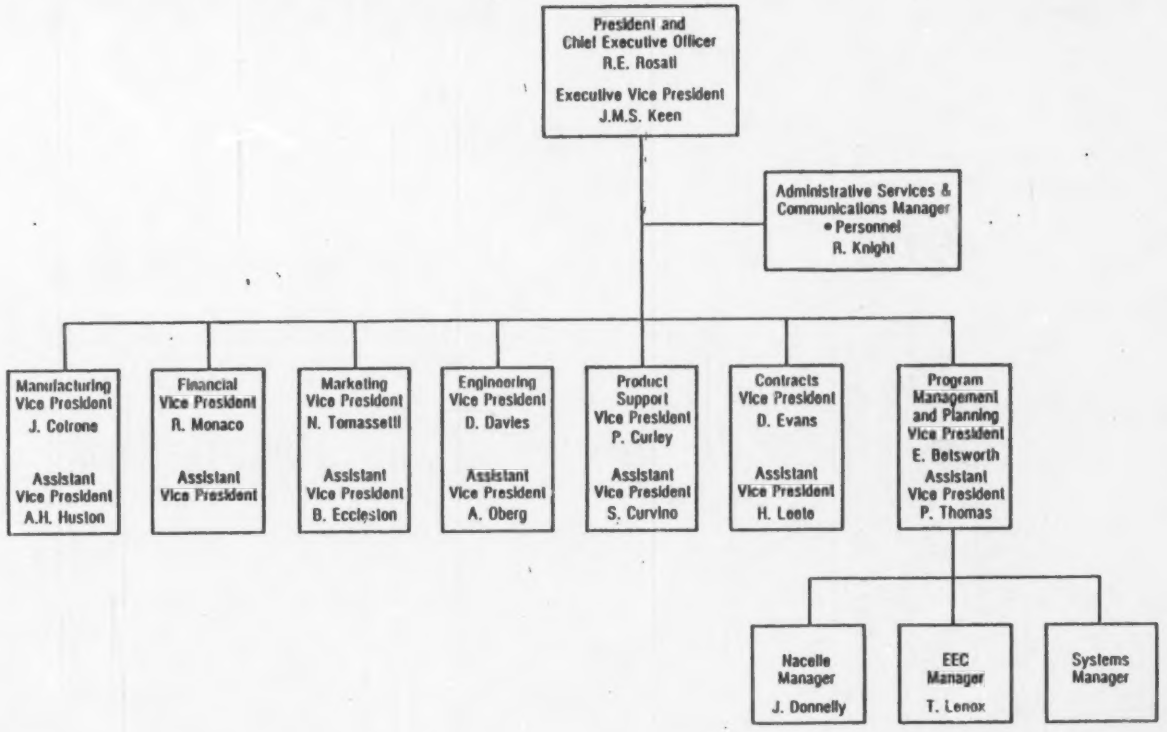
# IAE MANAGEMENT ORGANIZATION

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# IAE COMPANY FUNCTIONS

- Direct design, development, and manufacture
- Sell powerplants, engines, modules, and spare parts
- Provide product support
- Maintain programme continuity



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R840220 A271

# IAE IS BACKED BY THE TECHNICAL AND FINANCIAL ASSETS OF THE PARTNER COMPANIES

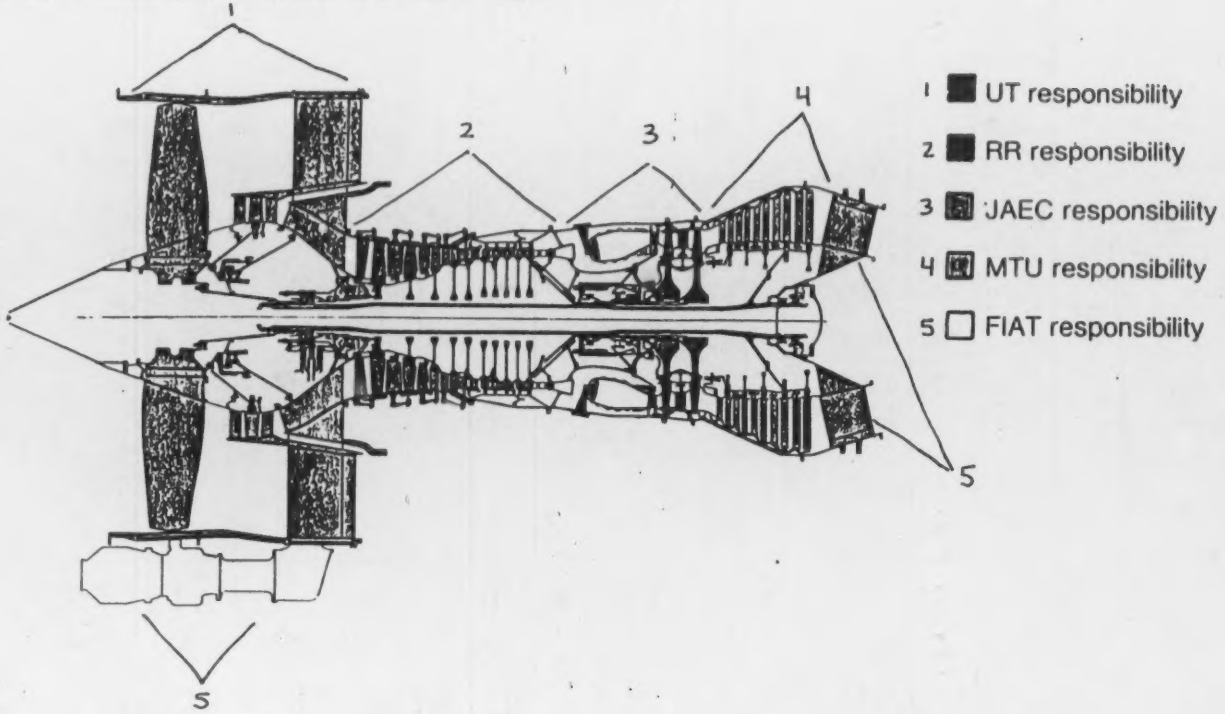
| Company | Parent | Fortune Int'l 500 rank | — Billions $ — 1982 sales | Assets | Employees |
|---|---|---|---|---|---|
| Pratt & Whitney | United Technologies | 20* | $13.6 | $ 8.0 | 184,000 |
| MTU | Daimler-Benz AG | 14 | $16.0 | $ 9.7 | 186,000 |
| Fiat Aviazone | Fiat SPA | 19 | $15.3 | ~$10.0 | 264,000 |
| MHI | — | 26 | $13.2 | $16.4 | 95,000 |
| IHI | — | 107 | $ 4.2 | $ 7.0 | 42,000 |
| KHI | — | 120 | $ 3.9 | $ 4.6 | 28,000 |
| Rolls Royce | — | 179 | $ 2.6 | $ 2.0 | 46,000 |
| Total | | | $68.8 | $58 | 845,000 |

*U.S. rank

J29603-8
R840501 A

# INTERNATIONAL AERO ENGINE

## DEVELOPMENT SPLIT



38-613 O—84—5

# MARKET

## AIRCRAFT

| | 1989-2004 |
|---|---|
| 120 passengers | 890 |
| 150 passengers | 2190 |
| 180 passengers | 200 |
| | 3280 |

# MARKET

## ENGINES

| | 1989-2004 |
|---|---|
| Installed engines | 6560 |
| Spare engines | 1980 |
| | 8540 |



RAB12TX.005

# IAE V2500 FEATURES

## Five nation global program commitment

- Combines technological expertise of partner companies
- Blends skills of world's best manufacturing technology
- Product supported by engine industry's leaders

## Only new technology engine to serve 150 passenger market

- Designed for short-haul commercial operation
- Lowest fuel consumption and noise characteristics
- Complete propulsion package supplied to match airframe
- Superior operating economics and R.O.I.
- Best technology base for future advancement

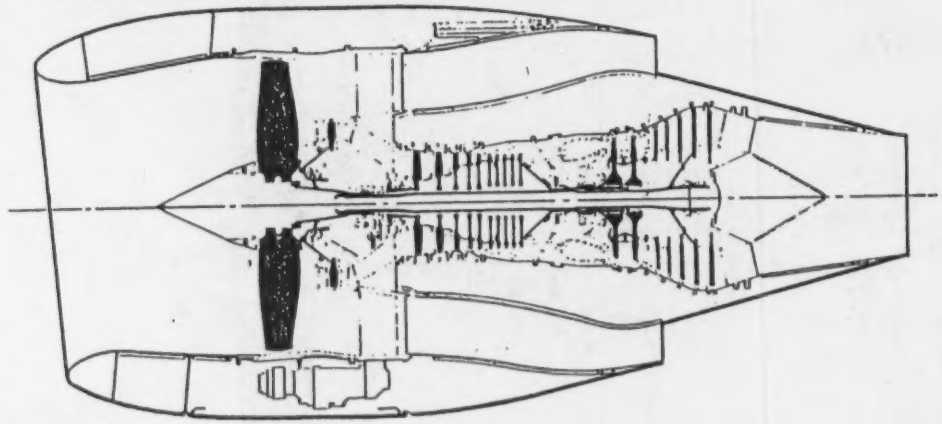
J29684-12
840501 E227

# V2500
# TECHNICAL DATA



J29664-18
930501 A

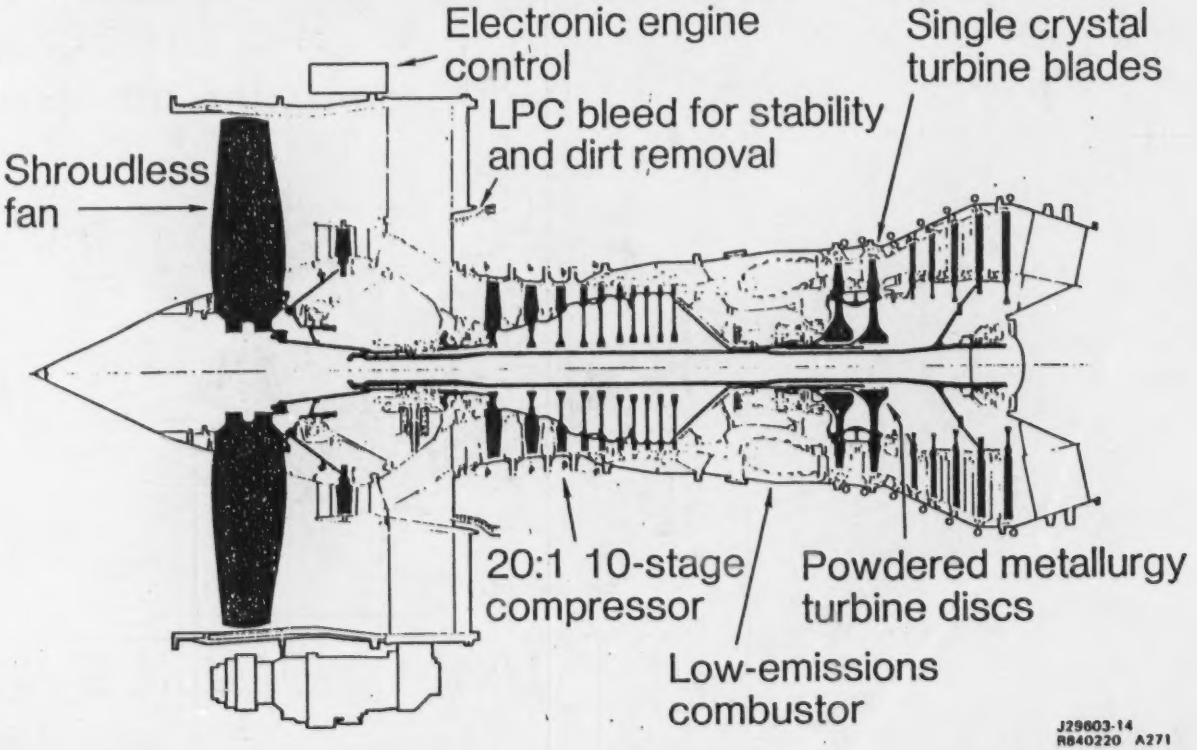
# IAE POWERPLANT



| | | |
|---|---|---|
| Take-off thrust (ideal), lbf | 23,000 | 25,000 |
| Fan tip diameter, in | 63 | 63 |
| Propulsion system weight, lb | 7300 | 7300 |
| Cruise TSFC, lb/lbf. hr | 0.585 | 0.591 |

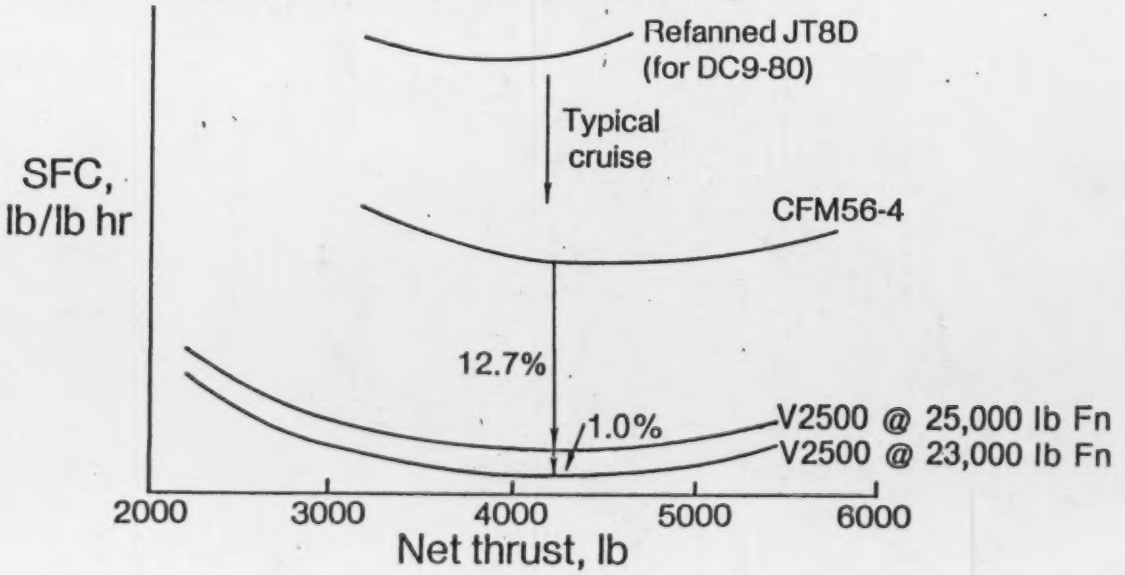
J29603-12
R842303

# IAE ENGINE-
# GENERAL ARRANGEMENT



# TSFC COMPARISONS

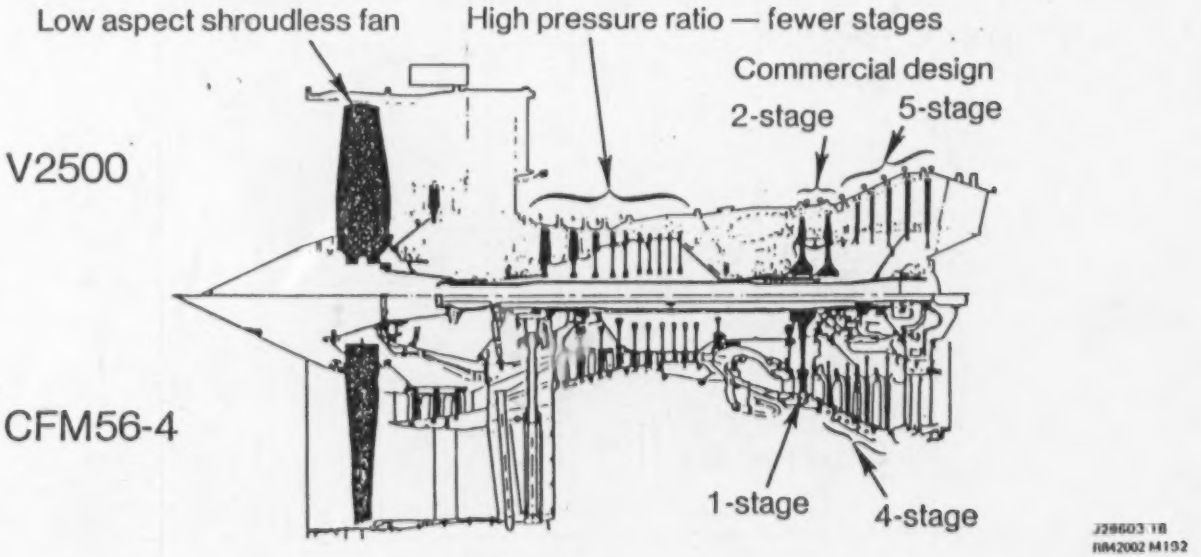
35,000 ft 0.8 Mn I.S.A. uninstalled. No scrubbing drag




J29664-22R
R842703

# FUNDAMENTAL DESIGN DIFFERENCES

## 14% BETTER FUEL BURN FOR THE V2500




J29603-18
IM42002 M192

# V2500 vs. CFM56-4 FUEL BURN COMPARISON AT 500NM

| | V2500 salient advantage | V2500 % fuel burn advantage |
|---|---|---|
| Fan | Shroudless blade<br>Quasi-3D aero | 4.5% |
| HPC | Prescribed velocity distribution airfoil | |
| HPT | Single crystal blades<br>2 stage design | 6.5% |
| LPT | Low loss airfoils<br>5 stage design | |
| Cycle | 36:1 max climb pressure ratio<br>Smaller core airflow | 3.0% |
| Installation | 62.0" fan diameter | |
| | *Total fuel burn advantage | 14.0% |

* @ 25,000 lb Fn rating



J29562 A
R842703

# SUMMARY

## THE IAE ENGINE

- Five nation collaboration
- Single point contact
- Designed for the '150' passenger market
- Design takes advantage of latest technology
- Lowest cost of ownership



J29852-89
840220 A271

## ENERGY

### JOINT EUROPEAN TORUS (JET)

Date of visit: September 10, 1984.
Location: Culham Laboratory, Abingdon, England.

Officials of the JET Organization who met with the Delegation were:

Dr. H.O. Wuster, Director.
Dr. P.H. Rebut, Deputy Director (Operation and Development).
Dr. R.J. Bickerton, Associate Director (Scientific).
Dr. G.W. O'Hara, Associate Director (Administration).
Mr. J. Maple, Director, Public Affairs.

Dr. Wuster presented a history of the JET activity and described the institutional arrangement at some length. He described how the OECD Steering Committee implements contracts with member states for priority capital projects, transfer of laboratory personnel, and support of JET operation testing and equipment installation (see Appendix A). The JET Council, which is supported by the Executive Committee and Scientific Council, requires a two-thirds vote to resolve any issue. The JET Joint Undertaking is also funding the Next European Torus (NET) activity to focus plasma technology, ultimately leading to design of the next OECD fusion device. The members develop five-year plans for budgeting every three years and each government group must effectively reach unanimity rather than simply a majority for a solid Council vote. The JET organization view is that in terms of their track record, "nothing succeeds like success" and the institutional arrangements have actually worked out very well. Mr. Winn raised the point that the JET arrangement seemed to work much better than the OECD parliamentary deliberations.

The JET project involves roughly 500 people working under somewhat abnormal circumstances in the sense that Euratom has a different salary structure than the U.K. Culham Laboratory and, as a result, there are salary discrepancies within identical job categories. The JET Council sets guidelines and it is the responsibility of the Director, the Deputy Director and the rest of the management team to execute the project. The present budget is about $100 million ECUs which is equivalent to $80 million, i.e., somewhat less than the Princeton Plasma Physics Laboratory (PPPL) budget for TFTR. The budget is broken down at about 50/50 between operations support (chiefly personnel) and capital equipment fabrication and installation, as well as diagnostic development and installation.

The JET group has meetings every nine months with the TFTR people and the agenda is set by the visiting group without DOE or the industrial participants present. The JET team is interested in

strengthening Doublet III cooperation, which is indicative of their interest in plasma shaping effects.

The performance of individual components on JET has been very impressive because of extreme pains taken in quality assurance and preinstallation testing. The JET project approach is to provide specifications to industry and leave them the flexibility to get the required performance levels using their own ingenuity. This is an iterative process and both parties are often wrong initially, but ultimately arrive at a satisfactory final design. The JET Procurement approach in contracts is not pro-rated by the contributing countries' share, but they are encouraged to strive for low bids while balancing this approach with the widest geopraphic spread for letting contracts. Obviously, on-site work for buildings and related civil engineering is done by U.K. contractors. The distribution of contractors is quite representative of the "industrial muscle" of the European community and there has only been one lost adjudication of a contract award made by the JET project.

Dr. Wuster noted that the Magnetic Fusion Energy program is a hybrid in the sense that it cannot be viewed as chiefly mission-oriented for at least another decade, but that it is not simply basic research (i.e., "curiosity oriented") because its logical development requires an evolutionary series of large experiments at increasing scale to demonstrate commercial power production.

The four major aims of JET are: (1) study of plasma parametric scaling laws approaching the power reactor regime; (2) investigations of plasma/wall interactions and the role of impurities in plasma cooling; (3) pursuit of various approaches to plasma heating (i.e., neutral beam and radio frequency); (4) study of alpha particle heating as a result of D–T burn experiments; in this case, a solid D–D base of machine experience is a definite prerequisite.

The cost-sharing of the OECD partners in JET was also discussed. The project is supported 80% by Euratom, 10% by the host country (the United Kingdom) and 10% by the research institutes in the various countries. As regards university interaction, which was an issue raised by Delegation members, 90% of plasma physics in Europe is done by the research institutes, i.e., the counterparts of our national laboratories, and only 10% is done at the university and then chiefly through the research institutes. The JET activity involves 20 man-years of associate staff support for which the Project pays expatriate (moving) costs only. The project also involves 75 research people working for Dr. Bickerton in experimental and theoretical work so that the total JET Joint Undertaking involves about 600 people.

In response to queries by Mr. Fuqua, Dr. Wuster outlined the manner in which JET involves industry. The project procurements are intentionally confined to contracts from participating countries and the U.S. firms are only a source of last resort and have received just 1% of the contracts. The bidders' list is not open to participants outside of the JET participating countries and this approach has worked very well thus far.

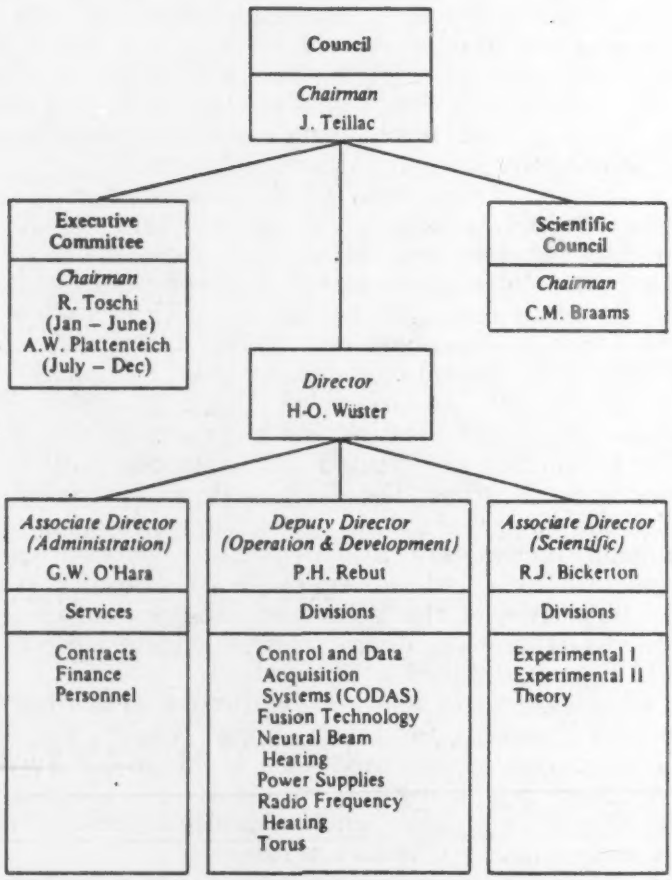
Dr. Rebut described the facility and its operating parameters in terms of magnetic field, plasma current, etc. JET operates at 3.5 tesla magnetic field and typically the current passed through the plasma is 2.4 megamps, and the maximum current thus far

achieved is 3.7 megamps. At a given current the extent of plasma elongation sets the limits on equilibrium and the plasma has gone unstable on a number of occasions. It went "wild" once, such that a force of 500 tons (i.e., five times the weight of the vacuum vessel) was produced and resulted in a one millimeter contraction in the dimensions of the device. The highest charge density achieved is $5 \times 10^{13}$ ions per centimeter$^3$, roughly the level of TFTR conditions, and the range of plasma temperatures achieved is from 2.5 to 5 kev (the higher temperature being achieved at lower densities). The pulse time of JET is from 10 to 15 seconds and confinement times achieved for a stable plasma are up to $^6/_{10}$ of a second. The JET has an impurity problem and $Z_{eff}$ is a measure of the impurity. The $Z_{eff}$ values indicate that impurities which lead to radiation losses at the edge of the plasma probably must be reduced by a factor of ten and impurity control is receiving a lot of attention. To have JET exceed break-even will require "all the plasma tricks," including reduction of impurities and successful application of neutral beam heating to achieve high temperatures at significant densities.

The visit concluded with a tour of the assembly area and test equipment area for JET support. The neutral beam heaters have not yet been installed; the first unit is undergoing installation and will be in operation by early next year. A second unit has been moved to its station by the main device, and a third unit is undergoing assembly in a test support cell. These units, each of which employ four separate ion sources, can deliver five megawatts of power to the plasma. RF Heating is also planned for the JET experiment; these additional Heating methods are described in Appendix B. The Delegation also visited the Assembly Hall, JET Control Room and general areas. The Control Room is similar to that for TFTR with the major exception that the machine operators setting the plasma parameters are physically isolated from the plasma diagnostics investigators (Appendix C). The JET results to date and the objectives of the Scientific Programme are summarized in Appendix D, and the diagnostics which are quite as extensive as for TFTR, are described in Appendix E.

The Delegation closed the visit with a discussion of future plans for JET and the prospects for international cooperation on NET and/or a TFCX device as the next step in Magnetic Fusion. Dr. Rebut believes there is a strong JET consensus that the next fusion machine should be a long-pulse, ignition device which provides virtually steady-state burning plasma conditions.

# Appendix A




*Organisation of the JET Joint Undertaking.*

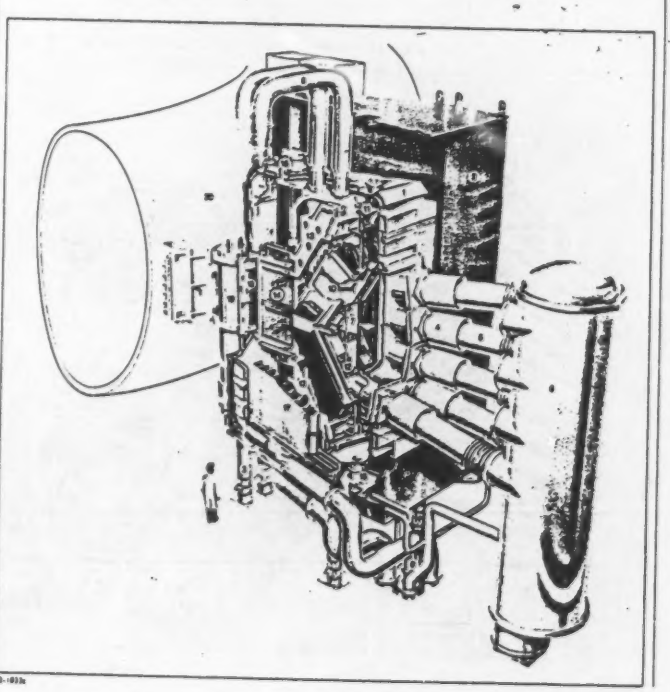
Appendix B

# Additional Heating

INITIAL heating of the gas on the JET experiment is carried out using the plasma current which also produces the poloidal magnetic field. Unfortunately, as the plasma resistance decreases with increasing temperature, resistive heating by the plasma current becomes increasingly less effective at higher temperatures. To reach temperatures high enough for abundant fusion reactions to occur, additional heating methods must be used. Two additional heating methods are being used on JET, neutral injection heating and radio-frequency heating.

## Neutral Injection Heating

Neutral injection heating is achieved by injecting an intense beam of energetic neutral atoms across the confining magnetic field into the plasma. There the neutral particles are ionised and confined by the magnetic field. The resulting energetic (suprathermal) ions give up their energy to the bulk plasma via collisions thus increasing its temperature. The technique of neutral injection heating has been successfully demonstrated on several of the present generation of tokamaks and plasma temperatures in excess of 75 million degrees have been achieved.



*Schematic of Neutral Injection System*

*1 Vacuum Tank*
*2 Magnetic Shielding*
*3 Support Structure*
*4 PINI Beam Source*
*5 High Voltage Termination*
*6 High Voltage Tower with Snubbers*
*7 Central Support Column*
*8 Main Cooling Pipes*
*9 Coolant Supply Lines*
*10 Bending Magnet with Cooled Liner*
*11 Magnet Electrical Supply Cables*
*12 Fractional Energy Ion Dump*
*13 Full Energy Ion Dump*
*14 Calorimeter*
*15 Calorimeter Drive*
*16 Turbomolecular Vacuum Pump*
*17 Cryopump System*
*18 Fast Shutter*
*19 Rotary Valve*
*20 JET Torus*

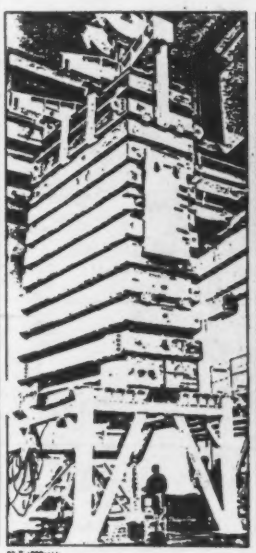
Although the basic physics of both the production of energetic neutral beams and the subsequent interaction with the plasma are well understood, injection requirements for JET have required a substantial extension of technology in terms of total power and pulse duration.

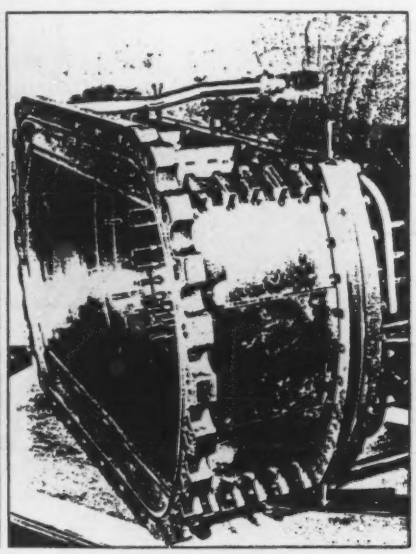
**Joint Design Team**

In order to meet these requirements a joint design team was formed drawing mainly upon expertise in the Associated Laboratories of Fontenay-aux-Roses (France) and Culham Laboratory (UK). This joint team was responsible for the development of the physics and technology needed to meet the required specifications. The Culham Laboratory's contribution is orientated towards the development of high power 80 keV hydrogen beams with long pulse duration, while Fontenay applies itself to the problems associated with deuterium beams and higher voltage operation.

**The Neutral Beam Injectors for JET**

The neutral injection for JET is provided by two systems, each capable of delivering 5 MW of power to the plasma. Each neutral beam injection system uses eight plug-in neutral injectors (PINIs), with each injector capable of providing an equivalent hydrogen beam current of 60 amps at an energy of 80 keV. At a later stage in the experimental programme the voltage will be increased to 160 kV using deuterium beams.





*Neutral injector box being prepared for testing*

*The bucket-type plasma source of the JET prototype PINI after its first operation*

**Radio Frequency Heating**

For this method of heating, high power electromagnetic waves are radiated from antennae on the walls of the vacuum vessel. Power is coupled into the plasma by selecting the frequency of radiation (25 — 55 MHz on JET) to be equal to that of an ion species gyrating around the magnetic field lines at the centre of the plasma. At this Ion Cyclotron Frequency the ions are accelerated and leave the resonant region at the centre to give up their energy to the bulk of the plasma.

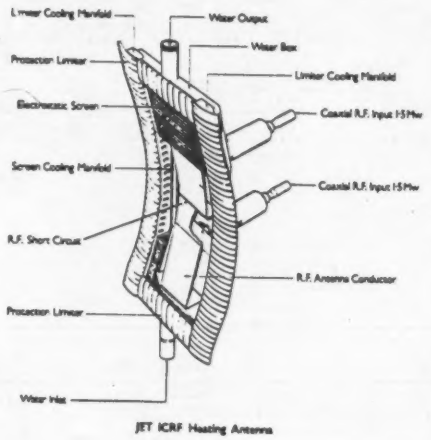
On the TFR tokamak at Fontenay-aux-Roses up to 2 MW of RF power has been coupled to the plasma, raising its temperature by more than 10 million degrees Centigrade without any apparent limitation due to the plasma density.

The ICRF heating system for JET has been evolved with the help of the Associated Laboratories involved in this research.

Ten RF generators will be used to produce the 30 MW of power required. The power from each generator is coupled into the upper and lower halves of an antenna by two 230 mm co-axial transmission lines. About 50% of the 30 MW of generated RF power will be coupled into the plasma. The generators situated in the north wing of the main building will use large tetrode electronic tubes, each one capable of providing 1.5 MW of radio-frequency power.

Development of the antennae presents a technological challenge as they are situated close to the plasma and are thus subjected to high mechanical and thermal stresses, high RF voltages and must also be capable of being installed remotely.

The 10 antennae will be distributed almost equally around the torus and they will be incorporated into the limiters attached to the walls of the vacuum vessel.




JET ICRF Heating Antenna

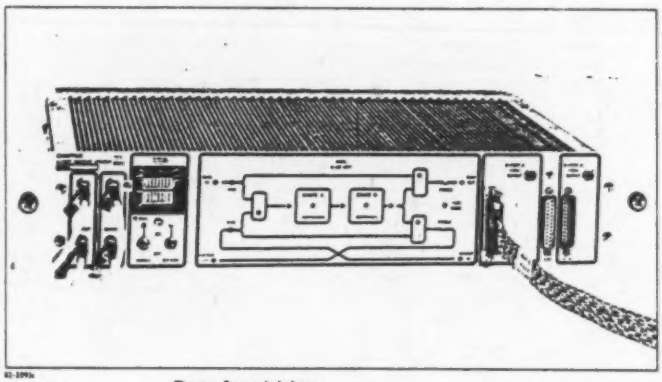
# Control Room

JET uses a computerised Control and Data Acquisition System (CODAS) to provide a flexible, easy and safe method of operating the experiment. This requires the interfacing and processing of more than 10,000 digital and 1,500 analogue signals.

**Control System**

Control and monitoring of the experiment is carried out using a network of 25 Norsk Data ND-100 and ND-500 mini-computers. The hierarchical structure of the control system reflects the way JET is made up from sub-systems (poloidal field, toroidal field etc.). Each computer is responsible for monitoring and controlling a part of the JET experiment with the overall supervision being performed by the two console computers. Any transfer of information between computers is carried out via the two communication computers. A real time data base holds a description of the JET experiment in the CODAS computers and forms the basis of all control and monitoring operations.

Signals between the JET machine and CODAS are taken via one of about 70 CODAS cubicles that contain interfacing electronics conforming to the CAMAC standard. Information is transferred between the computers and the cubicles situated around the site via 19 fibre-optic loops (Serial Highways) at a rate of 5 million bits per second.

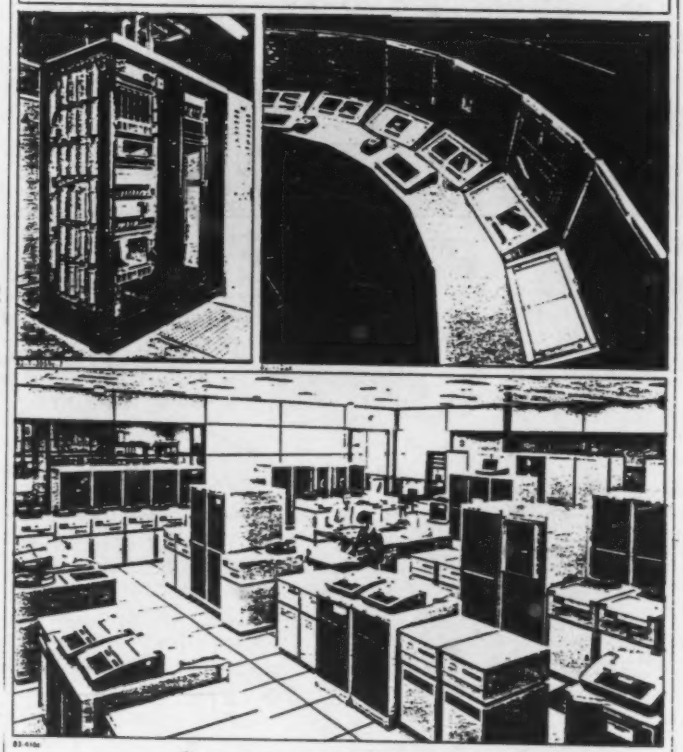


*"Serial highway U-port adapter"*

**Data Acquisition**

Acquisition of experimental data from the diagnostic equipment on the experiment requires in excess of 1 million items of data to be gathered during each pulse. The computers and interface electronics for the control and monitoring of the experiment are also used for data acquisition.

Filing of experimental data is performed by the largest computer in the Control Room, an ND-560, so that experimentalists can gain easy access to the information. The experimental data is then transferred to the large computers at Harwell for permanent archiving and more detailed evaluation.



*Codas cubicle for controlling the 132kV power supply system for JET*

*Operator console*

*Interior of the computer room in the control building*

Computer operators and experimentalists can communicate with the control system either via the two main consoles in the Control Room or through a number of mobile consoles. The following facilities can be used with these units:

1. Touch sensitive panels replacing conventional push buttons.
2. Colour television screens for displaying mimic diagrams of the JET systems, processed data in a graphical form or closed circuit television pictures.
3. Trackerballs, to allow identification of points on the screen, thus providing additional facilities to the touch sensitive panels.
4. Keyboards and display screens.
5. Black and white screens for closed circuit television pictures and high resolution graphic displays.

The control and interlock functions for JET are normally taken care of by the CODAS system. To ensure the safety of both personnel and the machine basic back-up interlock functions are provided by the Central Interlock and Safety System (CISS) which can automatically revert equipment into a safe state or inhibit JET pulses in the case of abnormal conditions or computer failures.

Appendix D

# JET Scientific Programme

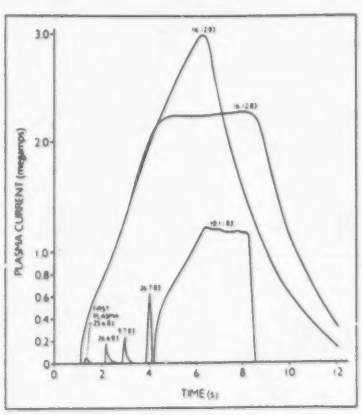
THE aim of the JET project is to obtain a plasma with a size, density and temperature comparable to the values needed in an eventual power producing reactor. This means producing a plasma with a diameter of about 2 metres, a density of 100 million million atoms per cubic centimetre and a temperature of 100 million degrees centigrade. Achieving these parameters on JET will be a major step forward, but many other difficult problems will have to be overcome before an economic fusion reactor can be built. The physics of plasmas is very complicated and not completely understood and it is therefore not certain that the JET apparatus will be able to produce plasmas with these parameters. The machine was designed between 1973 and 1975 and progress on smaller machines since then has confirmed the underlying ideas. JET is now considered to be the most advanced machine of its type in the world and is likely to remain so for at least a decade.

The plasma in a tokamak, such as JET, is heated by the very large electrical currents of up to 4.8 million amperes. Unfortunately this is totally inadequate to achieve the plasma temperatures required for nuclear fusion. Additional heating systems will therefore be added to JET over a number of years using two different methods:

1. The injection into the plasma of highly energetic neutral atoms (Neutral Injection heating) and
2. The coupling of high power electromagnetic radiation to the plasma (Radio Frequency heating).

The total power into the plasma will increase in discrete steps up to 25 megawatts.

Plasma was first produced in JET on 25 June 1983 as had been planned. The first plasma was sustained by a current of only some 17 thousand amperes lasting for 0.07 of a second.

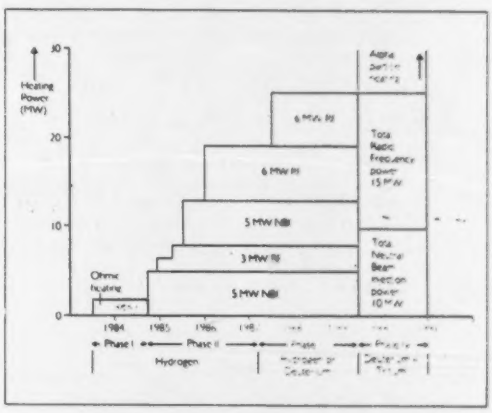



*Progress with JET Plasma current 26 June - 16 Dec 1983*

During the first period of operation up to December 1983 the current was progressively increased to a level of 3 million amperes with a total pulse duration in excess of 10 seconds. The voltage to drive this large current was a mere 1½ volts or so, showing that the central temperature approached 20 million degrees centigrade and that the plasma energy containment time approached a quarter of a second.

The performance of JET in the period up to December 1983 reached the best expectations of the project and marked the beginning of the experimental programme which extends to the end of the decade.

Between 1984 and 1988 new heating systems will be progressively added onto the machine, starting with 5 megawatts of additional heating and finishing with a total capacity of 25 megawatts. After each annual step increase in heating power the machine will be run for about nine months to establish its performance.




*JET Scientific Programme*

At full power an average temperature of 50 million degrees at rather higher densities is expected; peak temperatures will typically be about twice the average values. If this can be achieved the machine will then be operated with a deuterium tritium plasma. The additional power deposited in the plasma by thermonuclear reactions would then cause the temperature to rise towards the required 100 million degrees. In the extremely optimistic case of ignition the external heating systems could be turned off and the plasma temperature would continue to rise until the end of the pulse. At the other extreme, the pessimistic result would be that the plasma will not reach high enough temperatures to justify the use of tritium. Whatever the outcome, JET will provide valuable and definitive information on the possibilities of fusion power development.

Appendix E

# JET Diagnostics

EXPERIMENTAL information about the properties of a plasma is obtained by making quantitative observations of the physical processes which can occur within the plasma. These processes are:

1. Collisions between plasma ions and neutral atoms, electrons and the impurity atoms (C, O, Ni, Cr, Fe) originating from the walls of the vacuum vessel.
2. Interaction between plasma particles and electromagnetic waves and emission by the plasma of electromagnetic energy.

The diagnostic systems on JET measure the properties of the plasma and are designed to yield all relevant parameters simultaneously in one single pulse. Most of the diagnostic systems have many channels to allow the parameters to be measured throughout the plasma volume. The high plasma temperature and the long duration of the pulse exclude measurements involving physical contact between the sensor and the plasma. Only passive and active beams of particles, light and other electromagnetic radiation are being used.

The design and construction of the diagnostics is mainly carried out by the Associated Laboratories in the member countries. Some systems and all of the interfaces are designed and procured by the Jet Joint Undertaking.

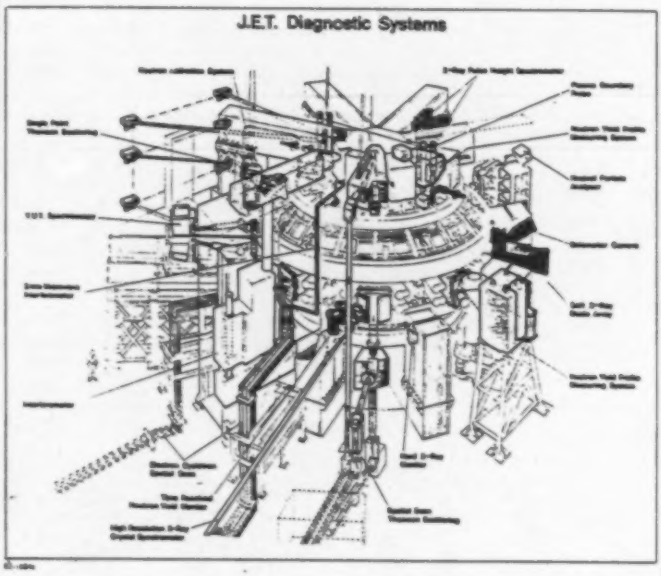
The philosophy underlying the JET diagnostics is that they must be able to operate for the whole experimental life of the machine. Because of the radiation problems during the deuterium-tritium phase the main detection systems are located outside the biological shield so that they can be easily maintained and repaired. The large distance between the machine and this area causes in many cases difficult alignment and signal transmission problems.

Among the more important diagnostics being used on JET are:

1. Magnetic diagnostics – A system of small coils and larger single loops, closely integrated with the vacuum vessel wall, picks up the magnetic field and fluxes outside the plasma. From these measurements plasma loop voltage, plasma current and the position of the plasma in the vessel can be derived.

2. Interferometers – Electrons in the plasma cause microwave or infrared waves to be delayed with respect to an external reference beam. This diagnostic enables values of the electron density to be obtained. The main interferometer has 7 vertical and 3 horizontal channels and the mirrors for reflecting the beams onto the detectors are located behind the environmental shield.

3. Spectrometers – The type, density and temperature of energetic atoms in the plasma determines the wavelength and intensity of emitted light. By measuring these two parameters spectroscopy plays a major role in the understanding of plasma behaviour.




*Schematic of JET diagnostics*

4. Thomson Scattering – High intensity pulsed laser light is scattered by electrons into specific directions. The intensity of this light depends on the electron density and its change in wavelength on electron temperature. Single point Thomson scattering looks at the light scattered through 90° and is the most reliable method to date for obtaining local values of electron density and temperature. The source and detectors are again located outside the environmental shield and there are severe alignment problems due to the large distances involved.

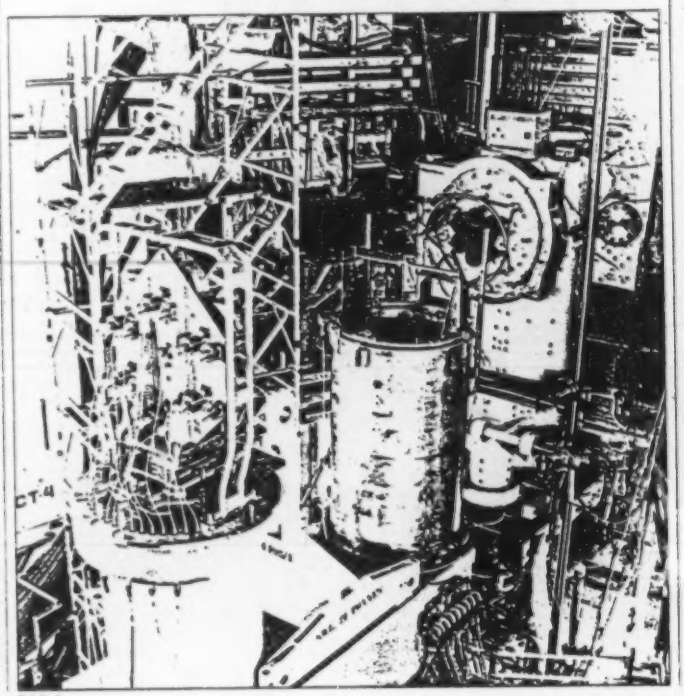
5. Neutral Particle Analyser – Neutral particles in the plasma are in thermal-equilibrium with the ions and because they are uncharged can easily escape from the magnetic confinement. The plasma ion temperature can therefore be determined by measuring the energy of escaping neutral atoms.

6. Bolometer – This detector essentially measures a broad spectrum of radiation representing the main radiation energy loss from the plasma. It consists of a thin foil with an absorber that receives the radiation and heats up. Coupled to this foil is a temperature-sensitive resistor which measures the thermal variation.

7. X-Ray Measurements – X-rays emitted by the plasma enable information about temperature, density and impurity content to be made. Special solid state detectors are employed in the soft X-ray diode array. This diagnostic is especially useful for observing fluctuations of the temperature but as the sensors are located close to the plasma, they will probably not be useful during the active phase.

8. Plasma Boundary Probe – Interactions between the plasma and the vacuum vessel can be determined by analysing wall material exposed to the plasma. Clean samples of wall material are exposed to the plasma from a special vacuum-tight container. After the exposure to one or more pulses the samples are removed and analysed using surface analysis techniques.

9. Neutron Measurements – Neutron diagnostics are planned because neutrons are produced as a result of fusion reactions occurring with the plasma. Observation of the intensity and energy distribution of these neutrons enables a direct measure of the reaction rate and consequently the density and temperature of the reactants.




*Part of the Thomson Scattering Diagnostic. Laser light scattered from the plasma is collected by the set of mirrors to the left and then deflected up into the roof laboratory for analysis*

## ENVIRONMENT

### NORWEGIAN INSTITUTE FOR WATER RESEARCH

Date of visit: September 10, 1984.
Location: Oslo, Norway.

On September 10, 1984, staff of the Committee visited the Norwegian Institute for Water Research (Norsk Institutt for Vannforskning, NIVA). NIVA is a national institute affiliated with Norwegian Council for Scientific and Industrial Research. Its main areas of research include: 1. environmental problems in lakes, rivers, and marine waters; 2. water resource management; and 3. engineering aspects of waste water and drinking water.

The delegation discussed research being conducted on acid deposition with the following scientists of NIVA and associated institutes:

Dr. Lars Overrein, Director General, Norwegian Institute for Water Research;

Dr. Richard Wright, Researcher, Norwegian Institute for Water Research;

Dr. Arne Henriksen, Researcher, Norwegian Institute for Water Research;

Dr. Harald Dovland, Researcher, Norwegian Institute for Air Research; and,

Dr. Hans Seip, Researcher, Central Institute for Industrial Research.

The purpose of the visit was to receive a briefing on acid precipitation from scientists of NIVA and associated institutes. Dr. Lars Overrein, Director General for NIVA, presented an overview on the Norwegian acid precipitation research program and an overall assessment of the acid rain problem in Europe. Dr. Overrein noted that the Norwegian and Swedish research programs were the earliest efforts to examine the phenomenon commonly referred to as acid rain. In 1972, Norway embarked on the largest multi-disciplinary research project in its history. That project—spanning eight years and costing $16 million—was directed at determining the effects of acid precipitation on forests and fish. The cooperative investigation involved more than 150 scientists and 12 Norwegian research institutes and culminated in a report entitled Acid Precipitation—Effects on Forests and Fish, released in March, 1980 at a scientific conference at Sandefjord, Norway. The report, a copy of which is on file with the Committee, is a highly documented analysis of the environmental impacts associated with acid rain.

Dr. Overrein noted that because of its geographic location and the fact that its bedrock is largely granite, Norway is extremely sensitive to acid deposition. Norway is downwind of Europe's major industrial centers and sources of pollution. Sulfur dioxide and ni-

trogen oxides emitted by these European industries are a major source of acid precipitation, principally through a process referred to as "scavenging" in which rainfall cleanses the atmosphere below rain clouds, removing the sulfates and nitrates and bringing them down as acids. Europe annually emits approximately 30 million tons of sulfur and 6 million tons of nitrogen oxides, much of which comes from tall smoke stacks. Norway's western coast is particularly exposed to emissions from Great Britain—Europe's largest source of sulfur emission. Sulfur and nitrogen gases emitted from tall stacks can be carried long distances on wind currents before being scavenged in acid precipitation. Dr. Overrein added that the European definition of the term "acid rain" also includes micropollutants (such as PCBs and DDTs) and metals (such as lead, mercury, and cadmium).

One half of Norway's precipitation falls in the form of snow. The accumulation of acid in the snow can prove extremely destructive when released suddenly in the first snow melt. Dr. Overrein provided graphic evidence of this phenomenon in photographs of a large-scale fish kill.

Dr. Overrein stated that the impact of acid deposition on Norway's lakes has been enormous. More than ten percent of Norway's lakes no longer support fish life. In addition, many more lakes will remain at risk if acid precipitation continues at the current rate.

Dr. Overrein also observed that the problems associated with acidification are no longer confined to Scandinavia. Large forest areas of central Europe appear to be seriously threatened by acid precipitation and direct injury from atmospheric gases. As a result of atmospheric deposition, particularly of sulfur, increased quantities of aluminum and cadmium are leached out of acidified soil and carried into groundwater and surface water. In the soil, dissolved aluminum interferes with the ability of plants to assimilate phosphorus and damages the fine root filaments of the trees.

Dr. Overrein stated that most European countries recognize both the serious threat that acid precipitation poses to the environment and the need for remedial action. He concluded with the observation that international cooperation—on both sides of the Atlantic—is necessary to attack the causes of acidification and that desulfurization of both fuels and stack gases is the only viable solution to the problem.

Dr. Harald Dovland of the Norwegian institute for Air Research (Norsk Institutt for Luftorskning, NILU) presented a briefing on how pollutants travel in the atmosphere and a summary of European air monitoring activities. Dr. Dovland observed that many questions of long-range transport of pollutants currently being debated in the United States (in conjunction with the reauthorization of the Clean Air Act) have been settled in Europe since the late 1970s. He described the structure of the European Monitoring and Evaluation Program, noting that while it functions in an adequate fashion, the program suffers from an overabundance of bureaucracy. The monitoring network consists of 80 stations throughout Europe, monitoring air quality and/or precipitation. In his view, the monitoring activities of the eastern European countries leave a great deal to be desired. Specifically, he stated that eastern European countries are presently providing only minimal data on pollutants and only ag-

gregate information on emissions, the latter being a particular problem with the material provided by the Soviet Union.

Dr. Dovland described the long-range transport computer model used to simulate the processes which control pollution transport. He noted that much of his work involved use of a grid model which analyzes air masses moving over a fixed number of points. Based on his modeling activities, Dr. Dovland has prepared an analysis indicating the principal sources of the pollution that is ultimately deposited in Norway and the approximate quantities generated by the respective sources. He stressed that, although the figures were only approximate, they were accurate within ten percentage points. He further observed that it is not necessary to establish a precise linear relationship between source and receptor. Rather, actions should be taken immediately to reduce all sulfur emissions by 30 percent. In Dr. Dovland's view, such a reduction would result in an overall reduction of approximately 35 percent of the acid deposition.

Dr. Hans Martin Seip of the Central Institute for Industrial Research described his work with conceptual models of fresh water acidification. He noted that it is still not possible to quantify precisely the contribution from the various processes involved in acidification. However, Dr. Seip indicated that acidification of fresh water may be best understood in reference to three conceptual models:

1. model based on direct effect; i.e., assuming that a substantial fraction of the precipitation reaches rivers and lakes unchanged;
2. model emphasizing increased deposition of mobile anions; and
3. model based on the effects on fresh water of a change in soil acidity (such a change may be caused either by acid precipitation or by other causes, such as changes in vegetation or in land use).

Dr. Seip stated that his research indicated that the fraction of precipitation reaching rivers and lakes essentially unchanged is normally small. Therefore, the direct effects are likely to be minimal in most cases. As to the third conceptual model, Dr. Seip observed that changes in soil chemistry may occur as a result of acid precipitation and this may contribute to fresh water acidification. He feels that such changes, although difficult to quantify, are not likely to account for a major part of the observed acidification of fresh water. Similarly, changes in patterns of land use do not appear to explain acidification, since there is no consistency in land application that would explain such a broadscale phenomenon as acidification.

Thus, according to Dr. Seip, acidification of fresh water is best understood by using the mobile anion concept. Sulfate anions associated with acid precipitation are highly mobile and in Dr. Seip's view, the increase of sulfate concentration in run-off water explains to a significant extent the acidification in lakes and streams. By means of relatively simple models, it is possible to approximate a particular ecosystem and the chemical processes that effect the acidification. The models of fresh water acidification have now reached the stage where they may give useful although not com-

pletely accurate predictions of water chemistry with changes in deposition. Dr. Seip noted that additional research is needed to refine predictive models of the response to changed emissions of sulfur dioxide and nitrogen oxides.

The staff was also briefed by Dr. Richard F. Wright, an American scientist with NIVA, on research projects currently underway in Norway. Dr. Wright briefly discussed Norway's experience with liming. In those instances where the lake does not have a rapid turnover of water, Norwegian scientists have experienced success with liming, with positive effects lasting for several years. But in those lakes where the water turnover time is less than one year, annual liming is necessary to produce beneficial effects. Accordingly, Norwegian scientists are experimenting with liming the watershed surrounding the lake rather than the lake itself. These experiments are still underway. Dr. Wright noted, however, that spreading large amounts of lime on areas surrounding lakes completely changes the character of the adjoining land. More importantly, Dr. Wright stressed that liming is only a partial and temporary solution. He suggests that liming should not be conducted at the expense of other efforts to eliminate the cause of acidification.

Dr. Wright also discussed a new research project entitled "RAIN" (Reversing Acidification in Norway). The project is designed to examine the question of what occurs when the deposition on a given body of water is changed. The experiment involves two small lakes: One is already acidified (a pH level of 4.2) and a second has a normal pH. A roof has been placed over the watershed catchment of the first lake so that all the naturally occuring rain fall is intercepted. The rainwater is converted to a normal pH level and then added to the lake through a sprinkling system. This aspect of the experiment is designed to yield results on what changes occur in water chemistry and at what rate (if at all) acidification will be reversed. The second lake is being artifically acidified by the infusion of acid into the snow pack and by means of the sprinkler system. The purpose of this experiment is to determine the nature and rate of acidification of sensitive lakes. Initial results from these experiments are anticipated within six months.

In concluding remarks, Dr. Overrein observed that recent developments provided encouraging signs that the Western European governments may soon reach a cooperative agreement to substantially reduce emissions of sulfur dioxide. He noted that the heavily industrialized nations on the European continent have now recognized the seriousness of the problem and appear willing to take corrective measures. Additionally, a recent report by the Committee on the Environment of the British House of Commons, which suggests that the United Kingdom must act to reduce sulfur emission by 30 percent, provides a further indication that E··-ope is nearing a consensus on controlling acid rain.

## University Research

### OXFORD UNIVERSITY

Date of visit: Sepember 10, 1984.
Location: Oxford, England.

The delegation visited Oxford University and discussed a number of science education related issues with the following individuals:

Dr. C. R. Brundin, University Lecturer in Engineering, Vice Chairman of the University's General Board.

Sir David Phillips, Professor of Molecular Biophysics, Chairman of the Advisory Board of the Research Councils.

Professor A. D. Smith, Professor of Pharmacology.

Dr. J. E. Allen, University Lecturer in Engineering.

Dr. W. G. Richards, University Lecturer in Physical Chemistry.

Professor J. B. Goodenough, Professor of Inorganic Chemistry.

Chairman Fuqua opened the discussion with an introduction of the Members of the delegation and a brief description of the responsibilities of the Committee on Science and Technology. He noted a particular interest in science policy and education and briefly discussed the legislation recently passed to attempt to increase the number of science and math teachers in secondary schools.

### Questions and Answers

Delegation: What types of research are emphasized at Oxford and how is the research funded?

University representatives: Research activities receive support primarily from the government from dual sources.

1. The university receives funding based upon recommendation of the University Grants Committee. This funding source primarily supports institutional and salary costs. The annual funding administered by the United Kingdom University Grants Committee is approximately 1300 million pounds.

2. The university receives funding from the United Kingdom Research Councils which administer an annual funding of approximately 530 million pounds. These funds support program related research.

Under the policies of the present government there has been increased support by industry for university research activities.

While funding administered by the Research Councils had experienced real growth up through 1975, this funding source has declined over the last four years.

In 1981 the government reduced overall support to universities by 14 percent; however, Oxford received only an 8 percent reduction.

Delegation: How are research priorities established?

University representatives: The government supports basic science across the board. The government selectively funds applied science or strategic science involving engineering development. Industry in the United Kingdom is less willing to shoulder risk than industry in the United States.

Delegation: How do universities support and maintain high quality professors?

University representatives: The present government has announced intention to move toward contracts of 5 to 10 years and away from tenured positions. In general one needs a secure professional position at an earlier age in the United Kingdom than in the United States.

Post graduate activities have been reduced less than undergraduate activities. Publicly funded Ph.D. activities have remained stable.

Delegation: Chairman Fuqua noted that there are currently 2000 faculty positions vacant in the United States and observed that this can most likely be attributed to higher salaries in industry.

University representatives: In the United Kingdom, a program called the New-Blood Lecturers program has been started which has supported 300 new lecturers under thirty-five years of age for each of the past three years. It is more difficult in engineering and in some sciences to get qualified candidates for this program.

Delegation: What are the components of governmental science policy?

University representatives: One cannot expect industry to support basic science. Government must assume this role. Industry should shoulder responsibility for applied research or near-term commercialization. In between is what is called strategic science with much of this activity in government laboratories. In the recent past the Research Councils have been putting more money into applied and strategic at the expense of basic.

From the point of view of policy, strategic science is the most difficult. If too narrowly defined, one will quickly work one's way out of a job.

Delegation: Is there a shortage of science and math teachers for secondary schools in Great Britain?

University representatives: One must look at incentives to keep science and math teachers in secondary schools. One must possibly consider paying science and math teachers more than others.

Delegation: What is the interaction between national laboratories and universities?

University representatives: There is some collaboration between national laboratories and universities. There is a deliberate policy to pursue this type of collaboration in large expensive science projects.

Delegation: Does the United Kingdom have a instrumentation problem similar to that in the United States?

University representatives: One of the successes of the United Kingdom system of dual support has been funding of instrumenta-

tion and equipment by the Research Councils. However, there is some problem in replacing and keeping instrumentation up to date.

Delegation: Do universities have access to government laboratories?

University representatives: Some government labs are available to universities; however, the United States is several steps ahead in this regard.

There is some concern in the United Kingdom with regard to the amount of defense related basic research which is unavailable to others.

University representatives: The United Kingdom views with importance international collaboration particularly in high energy physics and large science programs. What is the United States' view?

Delegation: The United States is hoping for continued and increased international participation.

Does Great Britain attempt to control the number of students in a given area?

University representatives: Medicine is the only area where the number of students is rigidly controlled. Also, selection of medical school candidates is made very early.

## UNIVERSITY OF OSLO

Date of visit: Tuesday, September 11, 1984.
Location: University of Oslo, Oslo, Norway.

The delegation was briefed by:

Dr. Egil Stangen, Executive Secretary, Natural Sciences Faculty.

Dr. Tore Amundsen, Dean, Natural Sciences College.

Dr. Stein-Arne Nilsen, Director, Biological Institute, and Chairman, Faculty Budget Committee.

Mr. Toralf Hernes, Division Head, Norwegian Technical-Scientific Institute.

The purpose of this visit was to obtain information about the Norwegian system for government support of basic and applied research in Norway's universities, about the training and utilization of science and engineering manpower in Norway, and about the attitude of Norway, as a representative of one of the smaller countries in Europe, toward international cooperation in science.

### *The Norwegian University System*

The University of Oslo is the largest university in the country. It has a science faculty of 319 which constitutes 30 percent of the total university faculty. The three other universities in the country are located at Trondheim on the West coast of Bergen in southwestern Norway and at Tromso in the North. Engineering education is offered chiefly at the Norwegian Institute of Technology, which is located at Trondheim, but which is separate from the university in the same city. More specialized engineering schools also exist, for example the institute for civil and shipbuilding engineering at Bergen.

### *Scientific Research Programs*

In the science departments of Oslo University, the number of entering students has grown steadily in recent years from 600 ten years ago to about 900 in 1983. The budgets for the science departments have grown correspondingly from a total of 11 million Norwegian Kroner ($1.25 million) to a total of 17 million Norwegian Kroner ($2.0 million) in 1983. The budgets of the individual departments and the size of their research faculty is shown in the following table:

RESEARCH AT OSLO UNIVERSITY—PHYSICAL SCIENCES DEPARTMENTS

[Budget amounts in millions]

| | 1983 budget | | Number of faculty |
|---|---|---|---|
| | NKr | US$ | |
| Physics | 4.8 | 0.56 | 84 |
| Biology | 4.0 | .47 | 70 |
| Chemistry | 3.9 | .45 | 60 |
| Geology | 2.3 | .28 | 49 |
| Mathematics | .9 | .01 | 37 |
| Pharmacology | 1.2 | .13 | 19 |
| Total | 17.1 | 2.00 | 319 |

*Science Education and Manpower*

Unlike the situation in the United States, all university professors in Norway are government employees. As civil servants their salaries are fully paid by the government and the pressure to obtain external research support to pay for all or part of their salaries is therefore less than it is in the United States. On the other hand, research expenses such as the cost of equipment and travel must also in most cases come from the central university budget.

Norway shares with much of the rest of the world the problem of insufficient faculty positions. More Ph.D.'s are being trained than the university market can accommodate. There is a certain amount of professorial "dead wood" and the Norwegian system is unlikely to devise anything self-correcting. This is not different from the situation in the United States.

In the sciences and engineering, however, the labor market is such that, between government and private enterprise, there are positions available at all levels for the products of the Norwegian educational system.

*Research Funding*

Funding for university research comes chiefly from the government. In the Norwegian Parliament, the single-chamber Storting, the Committee on Industry and Energy oversees government science programs and budgets. Within the government, however, the funding is disbursed by a diverse group of government agencies and research councils. The interaction between the many agencies involved and the detailed flow of research funds through them is complex and the delegation did not thoroughly trace the operation of the entire system in detail due to the limited time available. In addition to the government, the private sector also provides funds for university research. A particularly strong source of research funds in recent years has been the several oil companies, including Norsk Hydro which is 51-percent government owned, all of which have provided increased funds for university research. The sources of funds in 1981 are shown in the following table. Note that these funds are over and above the basic funding for the operation of the university, such as salaries, maintenance, etc., and cover only those funds provided directly for research activities:

SOURCES OF NATURAL SCIENCES RESEARCH FUNDS

| | Amounts (in millions) | | Percent |
|---|---|---|---|
| | NKr | U.S.$ | |
| Research councils | 43.0 | 4.9 | 62 |
| Mission agencies | 13.6 | 1.5 | 20 |
| Industry | 8.3 | .9 | 12 |
| Foundations, gifts | 2.7 | .3 | 4 |
| Other countries | 1.7 | .2 | 2 |
| Total | 69.0 | 7.8 | 100 |

*International Cooperation*

The university welcomes visting faculty researchers who wish to do research at Oslo and it sends scientists abroad to foreign universities and research centers such as the center for high energy research at CERN in Switzerland. In the area of big science, Norway is interested in participating, and the government has recently approved the decision to join the European Space Agency. However, when it comes to participating in the cost of construction of very large research instruments the costs are frequently prohibitive. While Norway in principle supports the idea of international cooperation in science, as a practical matter it is unlikely to be able to make major financial contributions to such projects.

## SPACE

### DEPARTMENT OF TRADE AND INDUSTRY

Date of visit: September 11, 1984.
Location: London, England.

Staff visited the Department of Trade and Industry for discussions with A. Clifford Nicholas, Director of the Space Branch, regarding space activities.

Responsibility for space activities in the United Kingdom is shared between a number of government departments and agencies. Of these, the Department of Trade and Industry [DTI] has had responsibility for civil space activities since May 1971. The Department is responsible for the industrial aspect of space activities and for technological research. The Department is also responsible for European applications satellite programmes.

The British civilian space program was originally an outgrowth of that Nation's military missile program, which began in 1956–57 with the development of the Blue Streak military rocket. At about that same time, the Black Knight sounding rocket was also developed by the British military. The two rockets would have been combined in the Black Prince project, which would have used Blue Streak as the first stage and Black Knight as the upper stages for a satellite launching vehicle. This project was scrapped with the cancellation of the Blue Streak program in April 1960. However, the technology from both Blue Streak and Black Knight had subsequent uses. Blue Streak was adapted to become the first stage of the ELDO launch vehicle, Europa, which the Europeans tried to develop throughout the 1960's. (Britain was one of the most vigorous advocates of European cooperative space efforts at that time.)

The United Kingdom does not have a separate organization for space which is analogous to NASA. Most of the United Kingdom space activities are conducted through participation in the European Space Agency. The British have emphasized application satellite activities while France has emphasized launcher activities (Ariane) and West Germany has emphasized manned space flight (Spacelab).

Space research has in the past not been given as high a priority as other science areas. Great Britain is relooking at the priority afforded space activities and many feel that the priority for space activities will increase in the future.

Great Britain is undertaking its own studies related to participation in the Space Station. A government-industry symposium is scheduled in early October as part of Great Britain's preparations for an upcoming European Space Agency Council meeting at which Europe's participation in the United States Space Station program will be discussed.



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